




DECLARATION

I, Toshizo Iida of Ishii Bldg., 3F, 1-10, Shimbashi 3-chome, Minato-ku, Tokyo, 105-0004 Japan, do solemnly and sincerely declare that I well understand the English and Japanese languages and that the attached English translation is correct and faithful translation, made by me, and for which I accept responsibility, of Japanese Patent Application No. 245931/1998 (Heisei 10), filed in Japan on August 31, 1998.

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(Title of the Invention) FIRE-RETARDANT RESIN COMPOSITION
AND WIRING MATERIAL USING THE
SAME

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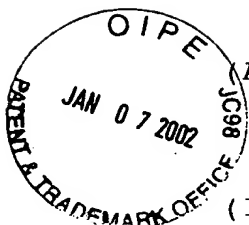
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(Name of Document) SPECIFICATION

(Title of the Invention) FIRE-RETARDANT RESIN COMPOSITION
AND WIRING MATERIAL USING THE SAME

(Claims)

(Claim 1) A fire-retardant resin composition, which
comprises:

a thermoplastic resin component (A) comprising (a) 100
parts by weight of a block copolymer made up of at least
two polymer blocks A mainly made of a vinyl aromatic
compound as its constitutional component and at least one
polymer block B mainly made of a conjugated diene compound
as its constitutional component, and/or a hydrogenated
block copolymer obtained by hydrogenating the block
copolymer, (b) 30 to 70 parts by weight of a nonaromatic-
series softening agent for rubber, (c) 10 to 60 parts by
weight of a polypropylene-series resin, (d) 50 to 200
parts by weight of an ethylene/ α -olefin copolymer having a
density of 0.91 g/cm³ or less that is synthesized in the
presence of a single site catalyst, and (e) 0.1 to 1.5
parts by weight of an organic peroxide; and

100 to 250 parts by weight of a metal hydrate (B),
to 100 parts by weight of the thermoplastic resin
component (A).

(Claim 2) The fire-retardant resin composition as claimed
in claim 1, wherein at least 100 parts by weight of the

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metal hydrate (B) is magnesium hydroxide that is being treated with a silane coupling agent.

(Claim 3) A wiring material, which has a covering layer of the fire-retardant resin composition as claimed in claim 1, on the outside of a conductor.

(Claim 4) The wiring material as claimed in claim 3, wherein at least 100 parts by weight of the metal hydrate (B) is magnesium hydroxide that is being treated with a silane coupling agent.

(Detailed Description of the Invention)

(0001)

(Technical Field to which the Invention Belongs)

The present invention relates to a fire-retardant resin composition excellent in mechanical characteristics and flexibility, as well as heat resistance, and to a wiring material in which said composition is used as a covering material on the outside of a conductor.

More specifically, the present invention relates to a fire-retardant resin composition preferably suitable as a covering material for insulated wires, cables, and cords, which are used for inner and outer wiring of electric/electronic equipment, etc.; and to a wiring material in which use is made of the same. More particularly, the present invention relates to a fire-retardant resin composition that neither exudes heavy

metal compounds nor produces a large amount of smoke or corrosive gases when discarded, for example, to be buried or burned, so that environmental problems may be cleared, and to a wiring material in which use is made of the same.
(0002)

(Prior Art)

Insulated wires, cables, and cords, which are used for inner and outer wiring of electric/electronic equipment, are required to have various characteristics, including fire retardancy, heat resistance, and mechanical characteristics (e.g. tensile properties and abrasion resistance).

For this reason, as the covering material used for these wiring materials, a polyvinyl chloride (PVC) compound and a polyolefin compound, wherein a halogen-series fire-retardant additive containing bromine atoms or chlorine atoms in the molecule is mixed, have been mainly used.

In some cases, however, when they are discarded or buried without being treated properly, the plasticizer or the heavy metal stabilizer mixed in the covering material is oozed out, or when they are burned, a corrosive gas is produced from the halogen compound contained in the covering material, in some cases; and in recent years, this problem has become controversial.

Therefore, wiring materials covered with a halogen-free fire-retardant material free from any risk of oozing out of toxic plasticizers or heavy metals, or generation of a halogen-series gas or the like, which involves concern about affecting the environment, are investigated.

Halogen-free fire-retardant materials secure their fire-retardancy by mixing a halogen-free fire-retardant additive in a resin. For example, a material obtained by mixing a large amount of a metal hydrate, such as aluminum hydroxide and magnesium hydroxide, as a fire-retardant additive, in an ethylene-series copolymer, such as an ethylene/1-butene copolymer, an ethylene/propylene copolymer, an ethylene/vinyl acetate copolymer, an ethylene/ethyl acrylate copolymer, and an ethylene/propylene/diene terpolymer, is used as a wiring material.

(0003)

The standards, for example, of the fire retardancy, the heat resistance, and the mechanical characteristics (e.g. tensile properties and abrasion resistance) required for wiring materials of electric/electronic equipment are stipulated in UL, JIS, etc. In particular, with respect to the fire retardancy, it is enough for the material to have at least the fire retardancy according to the required level. For example, mention can be made the

respective fire-retardancy to pass the vertical flame test (VW-1) stipulated in UL 1581 (Reference Standard for Electrical Wires, Cables, and Flexible Cords), or the horizontal test and the inclined test stipulated in JIS C 3005 (rubber/plastic insulated wire test method).

Hitherto, when a halogen-free fire-retardant material is made to have a fire retardancy high enough to pass VW-1 and the inclined test, it is necessary to mix 120 parts by weight or more of a metal hydrate, as a fire-retardant additive, in 100 parts by weight of a resin component, such as an ethylene-series copolymer. As a result, there is a problem that the mechanical characteristics, such as the tensile properties and the abrasion resistance, of the covering material are markedly lowered. To solve this problem, a measure is taken to lower the proportion of the metal hydrate (e.g. about 120 parts by weight of a metal hydrate, as a fire-retardant additive, to 100 parts by weight of a resin), and red phosphorus is added.

Meanwhile, wiring materials that are currently used in electric/electronic equipment, and whose covering material is a polyvinyl chloride compound or a polyolefin compound, wherein a halogen-series fire-retardant additive is mixed, are used by coloring them to be several respective colors, for example, by printing the surface of

electric wires, electric cables, and electric cords, for the purpose of distinguishing the types of wiring materials and junctions.

However, halogen-free covering materials having a metal hydrate and red phosphorus mixed therein, to secure both a higher fire retardancy and mechanical characteristics, cannot be printed thereon as the white, or they cannot be arbitrarily colored because of the color of the red phosphorus, so that they have the problem that they cannot give wiring materials that allow the types and junctions to be distinguished easily. Further, phosphorus, which will be released after discarding of the fire-retardant material containing phosphorus, poses also a problem that affects the environment; for example, pollution of water by eutrophication.

(0004)

Further, wiring materials used in electric/electronic equipment are sometimes required to have a heat resistance of 80 to 105 °C, or even 125 °C, with them being used continuously.

In that case, such a method is taken that the covering material is crosslinked by an electron beam crosslinking method, or a chemical crosslinking method, in order to render the wiring material highly heat resistant.

However, while the crosslinked wiring material is

improved in the heat resistance of the covering material, it is impossible to remelt it. Therefore it is pointed out that it is difficult to use said material again, making the recyclability thereof poor. For example, when a metal used as a conductor is recovered, the covering material has, for example, to be burned, in many cases, which means that the above environmental problem involving the conventional halogen- or phosphorus-containing covering material cannot be avoided.

On the other hand, as a technique wherein a wiring material having a heat resistance, on the order of 105 °C, is realized without carrying out such crosslinking, there is a technique wherein a resin having a high melting point, such as a polypropylene-series resin, is used. However, although such a resin is good in heat resistance, the flexibility is poor, and when the wiring material covered with such a resin is bent, a phenomenon is observed that the surface is whitened.

This whitening phenomenon is not observed in wiring materials currently used in electric/electronic equipment and covered with a polyvinyl chloride compound. On the other hand, in the case of wiring materials covered with a halogen-free fire-retardant material wherein a large amount of a metal hydroxide is mixed, this whitening phenomenon is conspicuous regardless of whether they have

been subjected to the crosslinking process or not. Thus, to use the current halogen-free fire-retardant material, which is whitened when bent, for wiring materials, further improvement has been required.

Since the maximum service temperature of a wiring material covered with a polyvinyl chloride compound is on the order of UL 105 °C, a halogen-free fire-retardant material for use as a replacement for the wiring material is also required to have that heat resistance. Specifically, since, for a heat resistance of UL 105 °C, for example, the heat deformation test and the heat aging test in an atmosphere at 136 °C are required, the halogen-free fire-retardant material, as a replacement, is required to not melt at at least 136 °C.

(0005)

(Problems that the Invention is to Solve)

An object of the present invention is to provide a fire-retardant resin composition that solves the above problems, that is excellent in fire retardancy, heat resistance, and mechanical characteristics, and that neither exudes heavy metal compounds nor produces a large amount of smoke or corrosive gases when discarded, for example, to be buried or burned, so that recent environmental problems may be cleared. Another object of the present invention is to provide a wiring material that

solves the above problems, that is excellent in fire retardancy, heat resistance, and mechanical characteristics, and that neither exudes heavy metal compounds nor produces a large amount of smoke or corrosive gases when discarded, for example, to be buried or burned, so that recent environmental problems may be cleared. Further object of the present invention is to provide a fire-retardant resin composition that gives a covering material that can be printed and be colored, and that can be remelted, to improve the recyclability thereof; that does not exhibit the whitening phenomenon as well as a polyvinyl chloride compound and wiring materials covered with the polyvinyl chloride compound, while satisfying the above characteristics. Still another object of the present invention is to provide a wiring material wherein said composition is used.

(0006)

(Means to Solve the Problems)

(1) A fire-retardant resin composition, which comprises: a thermoplastic resin component (A) comprising (a) 100 parts by weight of a block copolymer made up of at least two polymer blocks A mainly made of a vinyl aromatic compound as its constitutional component and at least one polymer block B mainly made of a conjugated diene compound as its constitutional component, and/or a hydrogenated

block copolymer obtained by hydrogenating the block copolymer, (b) 30 to 70 parts by weight of a nonaromatic-series softening agent for rubber, (c) 10 to 60 parts by weight of a polypropylene-series resin, (d) 50 to 200 parts by weight of an ethylene/ α -olefin copolymer having a density of 0.91 g/cm³ or less that is synthesized in the presence of a single site catalyst, and (e) 0.1 to 1.5 parts by weight of an organic peroxide; and

100 to 250 parts by weight of a metal hydrate (B), to 100 parts by weight of the thermoplastic resin component (A).

(2) The fire-retardant resin composition according to item (1), wherein at least 100 parts by weight of the metal hydrate (B) is magnesium hydroxide that is being treated with a silane coupling agent.

(3) A wiring material, which has a covering layer of the fire-retardant resin composition according to item (1), on the outside of a conductor.

(4) The wiring material according to item (3), wherein at least 100 parts by weight of the metal hydrate (B) is magnesium hydroxide that is being treated with a silane coupling agent.

(0007)

(Modes to Carry out the Invention)

Hereinbelow, the present invention is described in

detail.

First, the individual ingredients of the fire-retardant resin composition of the present invention are described.

(A) Thermoplastic Resin Composition

The thermoplastic resin composition (A) comprises (a) a block copolymer made up of at least two polymer blocks A mainly made of a vinyl aromatic compound as its constitutional component and at least one polymer block B mainly made of a conjugated diene compound as its constitutional component, and/or a hydrogenated block copolymer obtained by hydrogenating the block copolymer, (b) 30 to 70 parts by weight of a nonaromatic-series softening agent for rubber, (c) 10 to 60 parts by weight of a polypropylene-series resin, (d) 50 to 200 parts by weight of an ethylene/ α -olefin copolymer having a density of 0.91 g/cm³ or less that is synthesized in the presence of a single site catalyst; and (e) 0.1 to 1.5 parts by weight of an organic peroxide, respectively to 100 parts by weight of the thermoplastic resin composition (A).

Heating and kneading the thermoplastic resin component (A) in the present invention causes the ingredient (a) to be crosslinked, in the presence of the ingredient (e). On the other hand, by thermal decomposition, the ingredient (c) is made to convert to

have the molecular weight lowered suitably, so that the resultant composition gives a partially-crosslinked product excellent in extrudability in its entirety.

(0008)

(a) Ingredient: Block Copolymer

The ingredient (a) for use in the present invention is a block copolymer that is made up of at least two polymer blocks A, which is mainly made of a vinyl aromatic compound as its constitutional component, and at least one polymer block B, which is mainly made of a conjugated diene compound as its constitutional component, or it is a hydrogenated block copolymer obtained by hydrogenating the block copolymer, or it is a mixture of these. Examples of the ingredient (a) include a vinyl aromatic compound/conjugated diene compound block copolymer having a structure of A-B-A, B-A-B-A, A-B-A-B-A, or the like, or one obtained by hydrogenating the block copolymer. The above (hydrogenated) block copolymer (hereinafter, by a (hydrogenated) block copolymer is meant a block copolymer and/or a hydrogenated block copolymer) contains generally 5 to 60 % by weight and preferably 20 to 50 % by weight of a vinyl aromatic compound.

Preferably the polymer block A mainly made of a vinyl aromatic compound as its constitutional component, consists only of a vinyl aromatic compound, or it is a

copolymer block of a vinyl aromatic compound in an amount of generally over 50 % by weight and preferably 70 % by weight or more with a (hydrogenated) conjugated diene compound (hereinafter, by a (hydrogenated) conjugated diene compound is meant a conjugated diene compound and/or a hydrogenated conjugated diene compound). The polymer block B mainly made of a (hydrogenated) conjugated diene compound as its constitutional component, is preferably consisted only of a (hydrogenated) conjugated diene compound, or it is a copolymer block of a (hydrogenated) conjugated diene compound in an amount of generally over 50 % by weight and preferably 70 % by weight or more with a vinyl aromatic compound. In each of the polymer block A mainly made of a vinyl aromatic compound as its constitutional component and the polymer block B mainly made of a (hydrogenated) conjugated diene compound as its constitutional component, the distribution of the repeating units in the molecular chain, which are derived from the vinyl aromatic compound or the (hydrogenated) conjugated diene compound, may be a random distribution, a tapered distribution (one wherein the monomer component is increased or decreased along the molecular chain), a partial block distribution, or any combination of these. When there are two or more polymer blocks A mainly made of a vinyl aromatic compound as its constitutional component

or two or more polymer blocks B mainly made of a (hydrogenated) conjugated diene compound as its constitutional component, the structures thereof are the same or different.

(0009)

As the vinyl aromatic compound constituting the (hydrogenated) block copolymer, for example, one or more of styrene, α -methylstyrene, vinyltoluene, p-tert-butylstyrene, and the like can be chosen, with preference given to styrene. Further, as the conjugated diene compound, for example, one or more of butadiene, isoprene, 1,3-pentadiene, 2,3-dimethyl-1,3-butadiene, and the like are chosen, and among these butadiene, isoprene, and a combination of these are preferable.

As the microstructure of the polymer block B mainly made of a conjugated diene compound as its constitutional component, any microstructure may be chosen. For example, in the case of a polybutadiene block, those wherein a 1,2-microstructure amounts to 20 to 50 % and particularly 25 to 45 % are preferable, and those wherein at least 90 % of aliphatic double bonds derived from butadiene are hydrogenated are preferable. In the case of a polyisoprene block, those wherein 70 to 100 % by weight of the isoprene compound has a 1,4-microstructure and at least 90 % of aliphatic double bonds derived from the

isoprene compound is hydrogenated are preferable.

The weight-average molecular weight of the (hydrogenated) block copolymer used in the present invention that has the above structure, is preferably in the range of 5,000 to 1,500,000, more preferably 10,000 to 550,000, further preferably 100,000 to 550,000, and particularly preferably 100,000 to 400,000. The molecular weight distribution (the ratio (M_w/M_n) of the weight-average molecular weight (M_w) to the number-average molecular weight (M_n)) is preferably 10 or less, more preferably 5 or less, and further preferably 2 or less. The molecular structure of the (hydrogenated) block copolymer may be a straight-chain structure, a branched-chain structure, a radial structure, or any combination thereof.

(0010)

As the method for preparing the (hydrogenated) block copolymer, many methods have been proposed, and as a representative method, for example, a method described in JP-B-40-23798 ("JP-B" means examined Japanese patent publication) can be used, by which method block polymerization in an inactive solvent is carried out using a lithium catalyst or a Ziegler-type catalyst, to obtain the block copolymer. Further, for example, the block copolymer obtained by the above method may be hydrogenated

in an inactive solvent, in the presence of a hydrogenation catalyst, to obtain a (hydrogenated) block copolymer.

As specific examples of the above (hydrogenated) block copolymer, SBS (styrene/butadiene block copolymer), SIS (styrene/isoprene block copolymer), SEBS (hydrogenated SBS), and SEPS (hydrogenated SIS) can be mentioned. In the present invention, a particularly preferable (hydrogenated) block copolymer is a hydrogenated block copolymer that comprises a polymer block A mainly made of styrene as its constitutional component and a polymer block B mainly made of isoprene as its constitutional component, wherein 70 to 100 % by weight of isoprene has a 1,4-microstructure and at least 90 % of aliphatic double bonds derived from the isoprene is hydrogenated, and it has a weight-average molecular weight of 50,000 to 550,000. More preferably in the above hydrogenated block copolymer, 90 to 100 % by weight of isoprene has a 1,4-microstructure. (0011)

(b) Ingredient: Nonaromatic-series Softening Agent
(Softener) for Rubber

As the ingredient (b) for use in the present invention, a nonaromatic-series mineral oil, or liquid or low-molecular-weight synthetic softener can be used.

The mineral oil softener used for rubbers is a combined mixture of three of an aromatic ring, a naphthene

ring, and a paraffin chain, which is distinguished as follows: one wherein the number of carbon atoms of the paraffin chain amounts to 50 % or more of the total number of carbon atoms is referred to as paraffinic-series, one wherein the number of carbon atoms of the naphthene ring amounts to 30 to 40 % of the total number of carbon atoms is referred to as naphthenic-series, and one wherein the number of carbon atoms of the aromatic ring amounts to 30 % or more is referred to as aromatic-series.

The mineral-oil-series softener for rubber used as the ingredient (b) for use in the present invention, is one that is paraffinic-series or naphthenic-series as distinguished above. The use of an aromatic-series softener makes the ingredient (a) soluble, to inhibit the crosslinking reaction, which is unpreferable because the physical properties of the obtainable composition cannot be improved. As the ingredient (b), a paraffinic-series softener is preferable, and among paraffinic-series softeners, one having less aromatic ring component is particularly preferable.

Preferably the properties of these nonaromatic-series softeners for rubber are such that the kinetic viscosity at 37.8 °C is 20 to 500 cSt, the pour point is -10 to -15 °C, and the flash point (COC) is 170 to 300 °C.

The amount of the ingredient (b) to be added is 30

to 70 parts by weight and preferably 35 to 60 parts by weight, to 100 parts by weight of the ingredient (a). If the amount to be added is less than 30 parts by weight, the obtainable wiring material will lose the flexibility. On the other hand, if the amount to be added is over 70 parts by weight, the softening agent bleeds out readily, leading to a fear that the wiring material is made sticky and lowering the mechanical properties thereof.

Part of the ingredient (b) can be added after the heat treatment in the presence of the peroxide, but it may cause bleed-out in some cases.

Preferably the ingredient (b) has a weight-average molecular weight of 100 to 2,000.

(0012)

(c) Ingredient: Polypropylene Resin

As the polypropylene-series resin that can be used in the present invention, can be mentioned, for example, a homopolypropylene, an ethylene/propylene random copolymer, an ethylene/propylene block copolymer, and a copolymer of propylene with a small amount of another α -olefin (e.g., 1-butene, 1-hexene, and 4-methyl-1-pentene).

In the present invention, the ingredient (c), a polypropylene-series resin, can be used in such a way that part thereof is added after the heating (crosslinking), in the preparation of the resin composition (A) that is

heated to form a partially crosslinked product.

The polypropylene-series resin mixed in (A) before the heating (crosslinking) is thermally decomposed due to the presence of the ingredient (e) in the subsequent heating, thereby the molecular weight is suitably lowered.

As the polypropylene-series resin that is mixed before the heating, preferably one having an MFR (ASTM-D-1238, L conditions, 230 °C) of 0.1 to 10 g/10 min, more preferably 0.1 to 5 g/10 min, and further preferably 0.1 to 3 g/10 min is used.

If the MFR of the polypropylene-series resin is less than 0.1 g/10 min, even after the heat treatment, the molecular weight of the polypropylene-series resin is not lowered, making the moldability of the obtainable resin composition (elastomer) poor in some cases, whereas if the MFR of the polypropylene resin is over 10 g/10 min, the molecular weight is too lowered, making the rubber elasticity of the obtainable resin composition poor in some cases.

As the polypropylene-series resin that is mixed after the heating, one that meets the conditions at the time of extrusion for the formation of a covering layer is suitable, and preferably the MFR is 5 to 200 g/10 min, more preferably 8 to 150 g/10 min, and further preferably 10 to 100 g/10 min.

When the mixing is carried out after the heating, if the MFR of the polypropylene-series resin is less than 5 g/10 min, the moldability of the obtainable resin composition is made poor in some cases, whereas if the MFR is over 200 g/10 min, the rubber elasticity of the obtainable resin composition is made poor in some cases.

The amount of the ingredient (c) to be added, to 100 parts by weight of the ingredient (a), is from 10 to 60 parts by weight, preferably from 20 to 50 parts by weight. If the amount of the polypropylene-series resin (c) to be added is less than 10 parts by weight, there is a problem that the strength thereof is lowered very much and the deviation of extruding becomes large. Whereas, If the amount of the polypropylene-series resin (c) to be added is over 60 parts by weight, there is a problem that the resin composition becomes hard, making the flexibility poor.

(0013)

(d) Ingredient: Ethylene/ α -Olefin Copolymer

As the ingredient (d) for use in the present invention, an ethylene/ α -olefin copolymer having a density of 0.91 g/cm³ or less synthesized in the presence of a single site catalyst, is used.

Preferably the ethylene/ α -olefin copolymer (d) is a copolymer of ethylene with an α -olefin having 3 to 12

carbon atoms, and as specific examples of the α -olefin, can be mentioned propylene, 1-butene, 1-hexene, 4-methyl-1-pentene, 1-octene, 1-decene, and 1-dodecene.

The density of the copolymer is 0.91 g/cm^3 or less, and preferably 0.905 g/cm^3 or less. If the density is over 0.91 g/cm^3 , there arises a problem that the flexibility of the resin composition and the wiring material coated with the composition is lowered because a high loading of the metal hydrate come to be difficult. There is no particular lower limit to the density, but generally the lower limit is 0.850 g/cm^3 .

Further, preferably the ethylene/ α -olefin copolymer (d) has a melt flow index (ASTM D-1238) of 0.5 to 30 g/10 min.

(0014)

To prepare the ethylene/ α -olefin copolymer (d) synthesized in the presence of a single site catalyst for use in the present invention, a known method described, for example, in JP-A-6-306121 ("JP-A" means unexamined published Japanese patent application) or JP-T-7-500622 ("JP-T" means a published Japanese translation of PCT international application) can be used.

The single site catalyst is one whose polymerization active point is single and it is high in polymerization activity, and the single site catalyst is also called as a

metallocene catalyst or a Kaminsky catalyst. The ethylene/ α -olefin copolymer synthesized using this catalyst is characterized in that the molecular distribution and the composition distribution are narrow.

Since the ethylene/ α -olefin copolymer synthesized in the presence of such a single site catalyst has, for example, a high tensile strength, tear strength, and impact strength, when it is used in a halogen-free fire retardant material (a covering material of a wiring material) that is required to be highly filled with a metal hydrate, there is obtained an advantage that the lowering of the mechanical characteristics due to the highly filled metal hydrate can be minimized.

In contrast, in comparison with the use of the usual ethylene/ α -olefin copolymer, the use of the ethylene/ α -olefin copolymer synthesized using a single site catalyst causes an increase in melt viscosity or a decrease in melt tension, causing a problem with moldability. In this regard, there is one wherein the moldability is improved by introducing long-chain branches using an asymmetric catalyst as a single site catalyst (Constrained Geometry Catalytic Technology) or forming two peaks in the molecular weight distribution by connecting two polymerization tanks at the time of the polymerization (Advanced Performance Terpolymer).

(0015)

Preferably, the ethylene/ α -olefin copolymer (d) synthesized in the presence of a single site catalyst used in the present invention, is the above one improved in moldability, and as examples thereof "AFFINITY" and "ENGAGE" (trade names) from Dow Chemical Co. and "EXACT" (trade name) from Exxon Chemical Co. are put on the market.

The amount of the ingredient (d) to be added, to 100 parts by weight of the ingredient (a), is from 20 to 200 parts by weight, preferably from 70 to 150 parts by weight. If the amount to be added is less than 50 parts by weight, it is difficult to highly fill the metal hydrate, causing a problem that the mechanical characteristics of the obtainable composition are lowered. On the other hand, if the amount of the ingredient (d) to be added is over 200 parts by weight, there arises a problem that the flexibility is lost and the nonaromatic-series softening agent for rubber bleeds out from the resultant composition.

(0016)

(e) Ingredient: Organic Peroxide

As the organic peroxide that can be used in the present invention, can be mentioned, for example, dicumyl peroxide, di-tert-butyl peroxide, 2,5-dimethyl-2,5-di-(tert-butyl peroxy)hexane, 2,5-dimethyl-2,5-di(tert-butyl peroxy)hexine-3,1,3-bis(tert-butyl peroxyisopropyl)benzene,

1,1-bis(tert-butyl peroxy)-3,3,5-trimethylcyclohexane, n-butyl-4,4-bis(tert-butyl peroxy)valerate, benzoyl peroxide, p-chlorobenzoyl peroxide, 2,4-dichlorobenzoyl peroxide, tert-butyl peroxybenzoate, tert-butyl peroxyisopropyl carbonate, diacetyl peroxide, lauroyl peroxide, and tert-butylcumyl peroxide.

Out of these, 2,5-dimethyl-2,5-di-(tert-butyl peroxy)hexane and 2,5-dimethyl-2,5-di-(tert-butyl peroxy)hexine-3 are most preferable, in view of the odor, the coloration, and the scorch stability.

The amount of the organic peroxide (e) to be added, to 100 parts by weight of the component (a), is in the range of 0.1 to 1.5 part by weight, and preferably 0.5 to 1.0 part by weight. If the amount to be added is less than 1 parts by weight, the required crosslinking cannot be obtained. On the other hand, if the amount to be added is over 1.5 parts by weight, the dispersion of a partially crosslinked material becomes poor, because the crosslinking proceed excessively.

(0017)

In the preparation of the fire-retardant resin composition of the present invention or the thermoplastic resin component (A) used therein, in case of a partially crosslinking treatment, the composition may be blended with a polyfunctional vinyl monomer, such as a

divinylbenzene and a triallylcyanurate, and polymethacrylate monomer, such as an ethyleneglycoldimethacrylate, a diethyleneglycoldimethacrylate, a triethyleneglycoldimethacrylate, a polyethyleneglycoldimethacrylate, a trimethylolpropanetrimethacrylate, and an allylmethacrylate as a crosslinking aid.

By using such a compound, a uniform and efficient partial crosslinking reaction can be expected at the time of the heating and kneading.

Particularly, in the present invention, triethylene glycol dimethacrylate is most preferable, because it can be easily handled, its compatibility with other ingredients is good, it has a peroxide solubilizing action, and it acts as a dispersing aid of the peroxide, to make the crosslinking effect at the time of the heating and kneading uniform and effective, to give a partially crosslinked thermoplastic resin (elastomer) whose hardness and rubber elasticity are balanced.

The amount to be added of the crosslinking aid used in the present invention is preferably in the range of 0.15 to 3.0 parts by weight and more preferably 0.75 to 2.0 parts by weight, to 100 parts by weight of the component (a). If the amount to be added is less than

0.15 parts by weight to 100 parts by weight of the component (a), the required crosslinking cannot be usually obtained. On the other hand, if the amount to be added is over 3.0 parts by weight, it is easy to form a crosslinking gel, because a polymerization of the redundant crosslinking aid proceeds excessively

Further, the amount of the crosslinking aid to be added is preferably about 1.5 to 2.0 times, the amount of the organic peroxide to be added, in terms of weight.

(0018)

Metal Hydrate (B)

In the present invention, the above-described thermoplastic resin component (A) is blended with a specified amount of the metal hydrate in order to provide with a fire-retardancy in the resin composition and the wiring material.

The metal hydrate that can be used in the present invention includes, but is not particularly limited to, for example, compounds having a hydroxyl group or water of crystallization, such as aluminum hydroxide, magnesium hydroxide, aluminum silicate hydrate, magnesium silicate hydrate, basic magnesium carbonate, and hydrotalcite, which can be used singly or as a combination of two or more.

Among these metal hydrates, magnesium hydroxide is

preferable. As the magnesium hydroxide, commercially available Kisma 5 (trade name, manufactured by Kyowa Kagaku Co.) and the like is preferably, and a commercially available product of magnesium hydroxide whose surface has been already treated (e.g., Kisma 5A, Kisma 5B, Kisma 5E, Kisma 5J, and Kisma 5LH) is particularly preferably.

The amount of the metal hydrate (B) to be added in the resin composition of the present invention is 100 to 250 parts by weight, and preferably 120 to 230 parts by weight, to 100 parts by weight of the thermoplastic resin component (A). In the present invention, if the amount of the metal hydrate (B) to be added is less than 100 parts by weight to 100 parts by weight of the component (A), it is difficult to pass the horizontal test stipulated in JIS, because the fire-retardancy thereof becomes insufficient. On the other hand, if a large amount of the metal hydrate (B) is added, it comes to pass the vertical flame test stipulated in UL, however, if the amount of the metal hydrate to be added is over 250 parts by weight to 100 parts by weight of the thermoplastic resin component (A), the mechanical strength, such as the tensile strength and the tensile elongation, is lowered very much.

Particularly, in the present invention, as at least 100 parts by weight of metal hydrate to be used, preferably a magnesium hydroxide whose surface is treated

with a silane coupling agent is used. Thereby, the tensile strength of the obtained fire retardant resin composition and wiring material coated with the composition can be improved. Preferably, the silane coupling agent used in the surface treatment of a magnesium hydroxide is mentioned vinylsilan, vinyltrimethoxysilane, vinyltriethoxysilane, aminopropyltrimethoxysilane, aminopropyltriethoxysilane, glycidoxypropyltrimethoxysilane, methacryloxypropyltrimethoxysilane, and the like.

Further, the metal hydroxide (B) can be added later to the thermoplastic resin composition (A), which is obtained by heating and kneading the components (a), (b), (c), (d), and (e). Preferably, the metal hydroxide B is heated and kneaded together with the other components (a) to (e) in view of improvement of the mechanical properties. (0019)

A partial crosslinking molded part of the thermoplastic resin composition (A) of the present invention have flexibility and, further, properties which not only whitening difficultly occurs when bent, but also in case of the addition of a large amount of fillers, such as a metal hydroxide, whitening difficultly occurs when bent. When a polyolefine resin, such as polyethylene resin and polypropylene resin, is used as a base resin, in

case of the addition of a large amount of the metal hydroxide, the mechanical strength is lowered very much. By using the thermoplastic resin composition (A) as the base resin, when the filler is mixed, the lower of the mechanical strength is minimized, satisfactory characteristics for covering materials of wiring material can be obtained. (0020)

Into the fire-retardant resin composition of the present invention, can be blended various additives generally used in electric wires, electric cables, and electric cords, such as an antioxidant, a metal inactivator, a fire-retardant (auxiliary) additive, a filler, a lubricant, and an acid anhydride and its modified product, in the range wherein the purpose of the present invention is not damaged.

As the antioxidant, can be mentioned, for example, an amine-series antioxidant, such as a polymer of 2,2,4-trimethyl-1,2-dihydroquinone, 4,4'-dioctyldiphenylamine, and N,N'-diphenyl-p-phenyldiamine; a phenol-series antioxidant, such as pentaerythrityl-tetrakis(3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate), octadecyl-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate, and 1,3,5-trimethyl-2,4,6-tris(3,5-di-t-4-butyl-4-hydroxybenzyl)benzene; and a sulfur-series antioxidant, such as a bis(2-methyl-4-(3-n-

alkylthiopropionyloxy)-5-t-butylphenyl)sulfide, 2-mercaptobenzimidazole and its zinc base, and pentaerythritol-tetrakis(3-lauryl-thiopropionate).

As the metal inactivator, can be mentioned, for example, N,N'-bis(3-(3,5-di-t-butyl-4-hydroxyphenyl)propionyl)hydrazine, 3-(N-salicyloyl)amino-1,2,4-triazole, and 2,2'-oxamidobis-(ethyl 3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate).

(0021)

Further, as the fire-retardant (auxiliary) additive and the filler, can be mentioned, for example, carbon, clay, zinc oxide, tin oxide, titanium oxide, magnesium oxide, molybdenum oxide, antimony trioxide, a silicone compound, quartz, talc, calcium carbonate, magnesium carbonate, zinc borate, and white carbon.

Particularly, a silicone compound, such as a silicone rubber and a silicone oil, has such an effect that it not only gives or improves fire retardancy, but also it controls the adhesion between the insulator (the covering layer containing the fire-retardant resin composition) and the conductor in the case of electric wires and cords as well as it gives lubricity in the case of cables, to reduce external scars. Specific examples of such a silicone compound that can be used in the present invention include such commercially available products as

"SFR-100" (trade name, manufactured by GE Co.) and "CF-9150" (trade name, manufactured by Toray Dow Silicone Co.).

If added, the silicone compound is added preferably in an amount of 0.5 to 5 parts by weight to 100 parts by weight of the component (a). If the amount is less than 0.5 part by weight, it is not substantially effective for fire retardancy and lubricity. On the other hand, if the amount is over 5 parts by weight, the outer appearance of electric wires, cords, and cables is deteriorated and the extruding speed is lowered to make the productivity poor in some cases.

As the lubricant, can be mentioned, for example, a hydrocarbon-series lubricant, an aliphatic acid-series lubricant, an aliphatic acid amide-series lubricant, an ester-series lubricant, an alcohol-series lubricant, and a metal soap-series lubricant.

As the acid anhydride and its modified product, can be mentioned, for example, maleic anhydride and a maleic anhydride-modified polyethylene. By using the acid anhydride or its modified product, the interaction between the polyolefins (the ingredients (c) and (d)) and the metal hydrate is improved. Thus, the mechanical physical properties can be improved. When added, to 100 parts by weight of the ingredient (a), preferably the acid anhydride is used in an amount of 3.0 to 8.0 parts by

weight and the modified product of an acid anhydride is used in an amount of 20 to 35 parts by weight.

(0022)

Into the fire-retardant resin composition of the present invention, can be introduced the above additive and another resin in the range wherein the purpose of the present invention is not impaired, but at least the above thermoplastic resin component (A) is to be its major resin components. Herein, "to be its major resin components" means that the above thermoplastic resin component (A) amounts to generally 70 % by weight or more, preferably 85 % by weight or more, and more preferably all of the resin components, in the resin components of the fire-retardant resin composition of the present invention.

The thermoplastic resin component (A) used in the present invention is mainly made of at least the above ingredients (a), (b), (c), (d), and (e). Herein, "mainly made of" means that the above-described ingredients (a) and (e) amounts to generally 70 % by weight or more, preferably 85 % by weight or more, and more preferably all of the ingredients, in the thermoplastic resin component (A).

(0023)

Hereinbelow, the method for preparing the fire-retardant resin composition and the wiring material of the

present invention is described.

At first, ingredient (a), all of ingredient (b), at least one part of ingredient (B) (preferably 50 to 100 % by weight, more preferably 70 to 100 % by weight, particularly preferable all of ingredient (B), to an amount of ingredient (B) to be used), and at least one part of ingredients (c) and (d) (preferably 5 to 100 % by weight, and more preferably 30 to 100 % by weight, to an amount of ingredient (c) to be used, and preferably 50 to 100 % by weight, and more preferably 70 to 100 % by weight, to an amount of ingredient (d) to be used), and further if necessary, various kinds of additive, such as a filler, an antioxidant, a light-stabilizer, and a colorant, is mixed to previously heat and knead in a first step. The kneading temperature is preferably 160 to 240 °C. As the kneading method, a means usually used for rubbers, plastics, and the like can be satisfactorily used and, for example, as an apparatus, a single-screw extruder, a double-screw extruder, a roll, a Banbury mixer, or various kneaders can be used. In this process, a fire-retardant resin composition wherein the ingredients are uniformly dispersed can be obtained.

In the second step, the ingredient (e) and, if necessary, a crosslinking aid and the like, are added to the resultant composition of the first step, then further

a partial crosslinking is generated by kneading under heating. In this case, the kneading temperature is preferably 180 to 240 °C. In this way, it can be given particularly preferable physical properties that the ingredients (a) to (d) are previously heated and kneaded to micro-disperse them, the ingredient (e) is added and they are heated and kneaded under heat treatment to obtain a partial crosslinking material. As the kneading method in this process, generally a double-screw extruder, a Banbury mixer, or the like, can be used.

In the above-described first and second steps, it is possible that these two steps are conducted as a single step, and each ingredient is mixed to heat and knead.

In a third step, the residue quantity of each ingredient is added to the partial crosslinking composition obtained by the second step to knead. In this case, the kneading temperature is preferably 180 to 240 °C. As the kneading method, generally a single-screw extruder, a double-screw extruder, a roll, a Banbury mixer, or various kneaders can be used. In this step, the reaction completes with processing of the dispersion of each ingredient simultaneously.

In the above-described first, second, and third steps, it is possible that these three steps are conducted as a single step, and all of each ingredient are mixed to

heat and knead.

Further, in the above-described first step, it is possible that the fire retardant resin composition of the present invention is obtained, after all amount of ingredients (c), (d), and (B) is added and then the second step is carried out.

(0024)

In the wiring material of the present invention, there is no particular restriction except that the outer circumference of a conductor is provided with at least one covering layer made of the above fire-retardant resin composition of the present invention, preferably formed by extrusion coating. As the conductor, for example, any known one, such as a solid wire or a stranded wire of annealed copper, can be used. Further, as the conductor, a conductor plated with tin or having an enameled insulating layer can be used, in addition to an open wire.

The wiring material of the present invention can be prepared by extrusion-coating the circumference of a conductor or an insulated wire, with the fire-retardant resin composition of the present invention, by using a general-purpose extrusion-coating apparatus. At that time, the temperature of the extrusion-coating apparatus is preferably about 180 °C at the cylinder part and about 200 °C at the crosshead part.

In the wiring material of the present invention, the thickness of the insulating layer (a covering layer made of the fire-retardant resin composition of the present invention) formed around the conductor is not particularly limited, but it is generally of the order of 0.15 to 5 mm. (0025)

Further, in the wiring material of the present invention, although the resin composition of the present invention which is a partial crosslinking material is preferably extrusion-coated to form a covering layer as it is, it is also possible to further crosslink the extruded covering layer in order to improve the heat resistance further. However, if this crosslinking is carried out, it becomes difficult to reuse (recycle) the covering layer as an extrusion material.

As a method for crosslinking, the usually practiced electron beam irradiation crosslinking method and chemical crosslinking method can be employed.

In the case of the electron beam crosslinking method, after the resin composition is extruded to form a covering layer, it is irradiated with an electron beam in a usual manner, to carry out the crosslinking.

The dosage of the electron beam is suitably 1 to 30 Mrad, and in order to carry out the crosslinking efficiently, the resin composition that will constitute

the covering layer may be blended with, as a crosslinking aid, a polyfunctional compound, such as a methacrylate-series compound (e.g. trimethylolpropane triacrylate), an allyl-series compound (e.g. trially cyanurate), a maleimide-series compound, and a divinyl-series compound.

In the case of the chemical crosslinking method, the resin composition is blended with an organic peroxide as a crosslinking agent, and after the extrusion is carried out to form a covering layer, it is subjected to crosslinking by heating in a usual manner.

(0026)

(Examples)

Hereinbelow, the present invention is described in more detail with reference to the following examples, but the invention is not limited to those.

In the followings, unless otherwise stated, numerical values mean part(s) by weight.

(0027)

Use was made of, as the ingredient (a), a hydrogenated styrene/isoprene block copolymer (SEPS), as the ingredient (a), a paraffin oil, as the ingredient (c), homo polypropylene (MFR: 8g/10 min), as the ingredient (d), an ethylene/1-octene copolymer having a density of 0.87 g/cm³ (d-1), or an ethylene/1-octene copolymer having a density of 0.915 g/cm³ (d-2), as the ingredient (e), 2,5-

dimethyl-2,5-di(t-butylperoxy)-hexane, and as the component (B), magnesium hydroxide whose surface had been treated with a vinyl silane (B-1), or magnesium hydroxide whose surface had been treated with an aliphatic acid (B-2), and these components were blended in the amount to be added as shown in Table 1, to prepare compositions, respectively.

(0028)

(Examples 1 and 2, Comparative examples 1 to 9)

In Example 1, each of ingredients shown in Table 1 were dryblended at room temperature and were heated and kneaded in a Banbury mixer, to prepare a resin component. In Example 2 and Comparative examples 1 to 8, each of ingredients shown in Table 1 were dryblended and were heated and kneaded in a double-screw extruder, to prepare a resin component. In Example 9, a commercially available polyvinyl chloride, in place of the resin composition, was prepared.

Then, using an extrusion-coating apparatus for production of electric wires, each of the resin compositions for insulation-covering that had been previously melted was extruded to cover a conductor (a stranded annealed copper wire with tinning having a diameter of 1.14 mm ϕ and composed of 30 wires each having a diameter of 0.18 mm ϕ), to prepare insulated wires having

an outer diameter of 2.74 mm, respectively corresponding to Examples and Comparative Examples.

(0029)

Regarding the thus-obtained insulated wires, the tensile properties, the abrasion resistance, the fire retardancy 1 (the horizontal flame test), the fire retardancy 2 (the 60°-inclined flame test), the fire retardancy 3 (the vertical fire retardancy test), the heat deformation rate test, the whitening test (whether there was observed a whitening phenomenon), the outer appearance. The results are also shown in Table 1.

Regarding the tensile properties, the tensile strength (MPa) and the breaking extension (elongation) (%) of the insulators (covering layers) of the insulated wires were measured under conditions with the bench mark distance being 25 mm and the rate of pulling being 50 mm/min. The extension is required to be 150% or more and the mechanical strength is required to be 10 MPa or more.

The abrasion resistance was evaluated using the test apparatus whose front view is shown in Fig. 1. The insulated wire (1), cut to a length of 75 cm with the conductor (1b) exposed by removing the insulating-covering layer (1a) at both of the opposite ends, was fixed on a horizontal table (2) with a clamp (3); and then a blade (5) was moved back and forth alternately (in the direction

shown by the arrow in the figure) 50 to 60 times per minute, over a length of 10 mm or more along the longitudinal direction of the insulated wire, with a load (4) of 700 gf being applied, until the insulating-covering layer was removed by the abrasion to allow the blade to come in contact with the conductor of the electric wire, the number required of the reciprocative movements of the blade being counted. A front view of the blade is shown in Fig. 2, wherein the blade (5) has a blade section having a width of 3 mm defined by two faces (5a, 5b) forming an angle of 90° and the curvature radius (R) of the tip of the blade section is 0.125 mm. The one wherein the number of the reciprocative movements of the blade at which it came in contact with the conductor of the electric wire was 1,000 or more was rated "○" which meant an acceptable one, and the one wherein that number was less than 1000 was rated "×" which meant an unacceptable one.

(0030)

In the horizontal flame test, the insulated wires were subjected to the horizontal flame test stipulated in JIS C 3005, and the one wherein the burning went out by itself within 30 sec was rated "○" which meant an acceptable one, and the one wherein the burning did not go out by itself within 30 sec was rated "×" which meant an

unacceptable one.

In the 60-degree flame test, the insulated wires were subjected to the 60°-inclined flame test stipulated in JIS C 3005, and the one wherein the burning went out by itself within 30 sec was rated "○" which meant an acceptable one, and the one wherein the burning did not go out by itself within 30 sec was rated "×" which meant an unacceptable one.

In the vertical flame test, the insulated wires were subjected to the vertical flame test stipulated in UL1581, and the acceptable one was rated "○", and the unacceptable one was rated "×".

The heat deformation rate was measured by carrying out the heat deformation test of UL1581 with the temperature being 136 °C and the load being 500 gf, to obtain the rate (%) of the deformation after the heating to before the heating. The one having a heat deformation rate of 50% or more cannot be practically used.

The whitening phenomenon whether it would be observed or not, was evaluated by the observation whether there was whitening when the insulated wire was wound around a mandrel having the same diameter as that of the insulated wire. After winding 6 times, if there was no whitening, it was rated "○", and if there was whitening, it was rated "×". The one rated "×" is practically

unpreferable.

The outer appearance was evaluated by the visual observation whether there was the variation of the outer diameter of the insulated wire and the state of surface thereof. If they was good, it was rated "○", and if the outer diameter thereof was unstable by variation thereof, the rough surface and the bleeding occurred, it was rated "×".

(0031)

The compounds that were used, as shown in Table 1, were as follows:

The thermoplastic resin component (A)

Ingredient (a): a hydrogenated block copolymer

Manufacturing company: Kuraray Co., Ltd.

Trade name: Septon 4077

Type: a styrene/ethylene/propylene/styrene copolymer

Styrene component content: 30% by weight

Isoprene component content: 70% by weight

Weight-average molecular weight: 320,000

Molecular weight distribution: 1.23

Hydrogenated rate: 90% or more

Ingredient (b): a nonaromatic-series softener for rubber

Manufacturing company: Idemitsu Kosan Co., Ltd.

Trade name: Diana Process Oil PW-90

Type: a paraffin-series oil

Weight-average molecular weight: 540

Aromatic component content: 0.1% or less

Ingredient (c): a polypropylene-series resin

Manufacturing company: Grand Polymer Co.

Trade name: CJ-700

Type: a homopolypropylene

Density: 0.9 g/cm³

(0032)

Ingredient (d): a single site catalyst-series ethylene/ α -olefin copolymer

(d-1)

Manufacturing company: Dow Chemical Japan Ltd.

Trade name: ENGAGE EG8100

Type: an ethylene/1-octene copolymer

Density: 0.870 g/cm³

(d-2)

Manufacturing company: Dow Chemical Ltd.

Trade name: AFFINITY FM1570

Type: an ethylene/1-octene copolymer

Density: 0.915 g/cm³

Ingredient (e): an organic peroxide

Manufacturing company: Nippon Oil and Fats Co., Ltd.

Trade name: Perhexa 25B

Type: 2,5-dimethyl-2,5-di(t-butylperoxy)-hexane

(0033)

(B) Metal hydrate

(B-1)

Manufacturing company: Kyowa Chemical Co., Ltd.

Trade name: Kisma 5LH

Type: magnesium hydroxide whose surface was treated
with a vinyl silane

(B-2)

Manufacturing company: Kyowa Chemical Co., Ltd.

Trade name: Kisma 5B

Type: magnesium hydroxide treated with an aliphatic
acid

(0034)

Other components

A crosslinking aid

Manufacturing company: Sin Nakamura, Inc

Trade name: NK ester 3G

Type: a triethyleneglycoldimethacrylate

A maleic acid-modified polyethylene

Manufacturing company: Mitsui Chemicals, Inc.

Trade name: ADMER XE070

Type: a maleic acid-modified polyethylene

A polyvinyl chloride

Manufacturing company: Riken Vinyl Industry Co., Ltd.

Trade name: IH-5439

Type: a polyvinyl chloride compound

A phenol-series antioxidant

Manufacturing company: Ciba-Geigy Co.

Trade name: Irganox 1010

Type: pentaerythritol tetrakis(3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate)

Table 1

Composit- ions		Example 1				Example 2				Comparative Example 1				Comparative Example 2				Comparative Example 3			
		Example 1				Example 2				Example 1				Example 2				Example 3			
	(a)SEPS	100				100				100				100				100			
	(b)Paraffin oil	40				40				100				40				40			
	(c)Homo polypropylene	33				33				33				5				33			
	(d1)Ethylene/1- octene copolymer (ρ 0.870g/cm ³)	133				133				133				133							
	(d2)Ethylene/1- octene copolymer (ρ 0.928g/cm ³)																	133			
	(e)Organic peroxide	0.66				0.66				0.66				0.66				0.66			
	Maleic acid-modified polyethylene	27				27				27				27				27			
	Maleic acid anhydride	6.6				6.6				6.6				6.6				6.6			
	Crosslinking aid	1.2				1.2				1.2				1.2				1.2			
	(B1) Mg(OH) ₂ treated with vinyl silane ^{*1}	110				160				125				160				145			
	(B2) Mg(OH) ₂ treated with aliphatic acid	55																			
	PVC																				
	Specific gravity	1.41				1.41				1.41				1.41				1.41			
	Hardness (HDA15 sec)	89				89				85				87				92			
	Tensile strength (Mpa)	14				22				16				14				8			
Propert- ies	Breaking extension (%)	160				180				170				200				70			
	Abrasion resistance	○				○				○				○				○			
	Fire retardancy 1	○				○				○				○				○			
	Fire retardancy 2	○				○				○				○				○			
	Fire retardancy 3	x				x				x				x				x			
	Heat deformation rate (%)	18				14				16				18				16			
	Whitening phenomenon	○				○				○				○				x			
	Outer appearance	○				○				x				x				○			

Table 1 (continued)

Composit- ions	Comparative							
	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9	Example 9	Example 9
(a)SEPS	100	100	100					
(b)Paraffin oil	40	40	40					
(c)Homo polypropylene	33	33	33	100				
(d1)Ethylene/1- octene copolymer (ρ 0.870g/cm ³)	30	133	133		100			
(d2)Ethylene/1- octene copolymer (ρ 0.928g/cm ³)								
(e)Organic peroxide	0.66	0.66	0.66					
Maleic acid-modified polyethylene	27	27	27					
Maleic acid anhydride	6.6	6.6	6.6					
Crosslinking aid	1.2	1.2	1.2					
(B1) Mg(OH) ₂ treated with vinyl silane ^{*1}	210	270	80	330	330			
(B2) Mg(OH) ₂ treated with aliphatic acid				165	165			
PVC								100
Specific gravity	1.41	1.68	1.17	1.41	1.41	1.33		
Hardness (HDA15 sec)	94	94	84	95	94	92		
Tensile strength (Mpa)	6	14	24	8	12	30		
Breaking extension (%)	50	40	360	80	500	400		
Abrasion resistance	x	x	○	x	x	○		
Fire retardancy 1	○	○	x	○	○	○		
Fire retardancy 2	○	○	x	○	○	○		
Fire retardancy 3	x	○	x	x	x	x		
Heat deformation rate (%)	18	12	14	4	Melted ^{*2}	12		
Whitening phenomenon	○	x	○	x	x	○		
Outer appearance	○	○	○	○	x	○		

(Note) *1 : Values are represented by parts by weight to 100 parts by weight of the resin compositions (total amount of components (a), (b), (c), (d1), (d2), and (e))

*2 : Test did not conduct because of melting by heating

(0036)

As is apparent from the results shown in Table 1, the insulated wire, coated by a fire-retardant resin composition, which comprises: a thermoplastic resin component (A) comprising (a) 100 parts by weight of a block copolymer made up of at least two polymer blocks A mainly made of a vinyl aromatic compound as its constitutional component and at least one polymer block B mainly made of a conjugated diene compound as its constitutional component, and/or a hydrogenated block copolymer obtained by hydrogenating the block copolymer, (b) 30 to 70 parts by weight of a nonaromatic-series softening agent for rubber, (c) 10 to 60 parts by weight of a polypropylene-series resin, (d) 50 to 200 parts by weight of an ethylene/ α -olefin copolymer having a density of 0.91 g/cm³ or less that is synthesized in the presence of a single site catalyst, and (e) 0.1 to 1.5 parts by weight of an organic peroxide; and 100 to 250 parts by weight of a metal hydrate (B), to 100 parts by weight of the thermoplastic resin component (A), is excellent with the mechanical characteristics, the fire retardancy, the heat resistance, and the flexibility.

Particularly, in comparison between Examples 1 and 2, and Comparative example 9, it is found that, in spite of the insulated wire coated by the fire-retardant resin

composition of the present invention is a insulated wire coated by the a halogen-free fire-retardant material, the insulated wire have properties equal to a insulated wire coated by polyvinyl chloride compound which is used in electric/electronic equipment currently, thereby the substitution thereof is possible.

(0037)

(Effects of the Invention)

The fire-retardant resin composition of the present invention is made up of a halogen-free fire-retardant material not containing phosphorus; accordingly, not only is the composition excellent in mechanical characteristics, fire retardancy, heat resistance, and flexibility, but also it neither exudes harmful heavy metal compounds nor produces a large amount of smoke or corrosive gases when discarded, for example, to be buried or burned.

Further, the wiring material of the present invention is excellent in mechanical characteristics, fire retardancy, and heat resistance, as well as flexibility, and particularly it is not whitened when bent. Thus, the wiring material of the present invention is a halogen-free fire-retardant wiring material not containing phosphorus that is excellent in both flexibility and mechanical strength.

Further, since the covering layer of the wiring

material of the present invention has a high heat resistance of UL 105 °C, and it can be made of a remeltable material as a covering material, a wiring material can be provided that is rich in recyclability, in comparison to conventional wiring materials covered with a current covering material that is a crosslinked product.

Thus, the wiring material of the present invention is very useful as a wiring material for electric/electronic equipment, such as power source cables, wherein environmental problems are taken into consideration. Further, the fire-retardant resin composition of the present invention is preferably suitable as a covering material for such a wiring material.

(Brief description of drawing)

(Fig. 1)

A front view of an apparatus for testing abrasion resistance.

(Fig. 2)

A front view of the blade in the apparatus for testing abrasion resistance, as shown in Fig. 1.

(Explanation of letters or numerals)

- 1. Insulated wire
 - 1a. Insulating-covering layer
 - 1b. Conductor
- 2. Table

3. Clamp

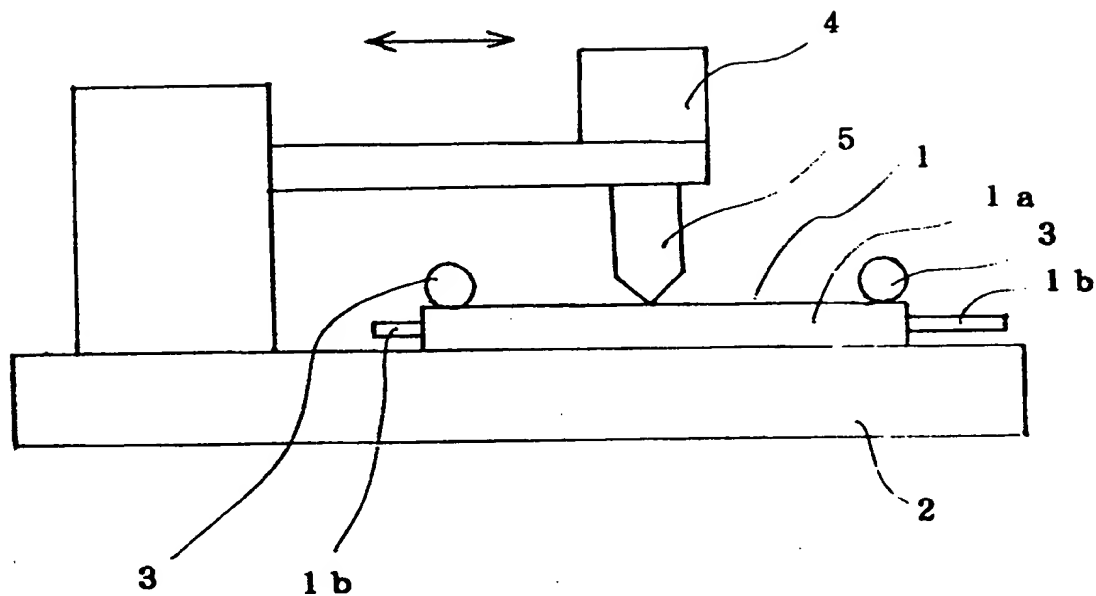
4. Load

5. Blade

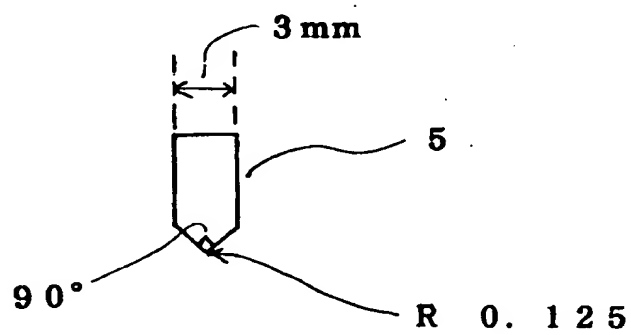
5a. 5b. Face of blade section

(Name of Document) DRAWING

(Fig. 1)



(Fig. 2)



(Name of Document) ABSTRACT

(Abstract)

(Problems) To provide a fire-retardant resin composition, excellent in fire retardancy, heat resistance, and mechanical characteristics, and it is not whitened when bent, and also it neither exudes heavy metal compounds nor produces a large amount of smoke or corrosive gases when discarded, for example, to be buried or burned, so that environmental problems may be cleared, and to a wiring material in which use is made of the same

(Means to solve) A fire-retardant resin composition, which comprises:

a thermoplastic resin component (A) comprising (a) 100 parts by weight of a block copolymer made up of at least two polymer blocks A mainly made of a vinyl aromatic compound as its constitutional component and at least one polymer block B mainly made of a conjugated diene compound as its constitutional component, and/or a hydrogenated block copolymer obtained by hydrogenating the block copolymer, (b) 30 to 70 parts by weight of a nonaromatic-series softening agent for rubber, (c) 10 to 60 parts by weight of a polypropylene-series resin, (d) 50 to 200 parts by weight of an ethylene/ α -olefin copolymer having a density of 0.91 g/cm³ or less that is synthesized in the presence of a single site catalyst, and (e) 0.1 to 1.5

parts by weight of an organic peroxide; and

100 to 250 parts by weight of a metal hydrate (B),
to 100 parts by weight of the thermoplastic resin
component (A).

(Selected Drawings) None

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(Name of Document) Date corrected by Virtue of
Official Authority

(Document corrected) REQUEST FOR PATENT

<Recognized Information · Added Information>

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(Addressed to)	Commissioner of the Japanese Patent Office
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